SECTION II.—GENERAL METEOROLOGY.

THE MICROBIC CONTENT OF INDOOR AND OUTDOOR AIR.

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[Dated, New York State Commission on Ventilation, Aug. 13, 1914.]

Determinations of the microbic content of the atmosphere have been reported by many observers since the first studies made by Pasteur along this line, yet the results have never been correlated and systematized so as to furnish standards which could be accepted as representing normal values for air from different sources. The New York State Commission on Ventilation, whose researches are supported by a generous gift from Mrs. Elizabeth Milbank Anderson, made through the New York Association for Improving the Condition of the Poor, decided that one of its tasks must be to digest the mass of published data upon this subject and to carry on such original work as might be necessary to establish such normal values for the microbic content of the atmosphere as are now at hand for its chemical constituents. The results of the new work of the commission along this line are briefly presented here.

A total of 353 samples of air were examined during the first six months of the present year, obtained from four different groups of sources, which we have classed under the headings: Country, City, Offices, and Factories. The samples of "Country air" (85 in number) were collected in woods and fields, on country roads and over water in suburban districts near New York City. The "City air" (134 samples) was obtained in the streets of New York City itself. The "Office" samples came from three different sources: Nineteen of them from a commercial office in downtown New York, 49 from a large commercial establishment on West Twenty-third Street, New York, and 19 from the United States Senate Chamber, Washington, D. C.—87 in all. Of the 47 "Factory" samples, 25 came from a cigar factory and 22 from a hat factory in New York City, representing crowded and somewhat dusty trades.

The samples of air were collected and examined by the methods prescribed by the Committee on Standard Methods for the Examination of Air of the American Public Health Association.[1] In each case 5 cubic feet of air were drawn through a 1-centimeter layer of 80-mesh sand by means either of a hand pump or of the ingenious air-sampling pump made by Wallace and Tiernan of New York and used by Prof. Charles Baskerville and the senior author in their study of air conditions in New York City schools.[2] On returning to the laboratory the microbes collected in the sand were washed out by shaking the sand up in 10 cc. of water and aliquot portions of the water were plated in the usual manner.

The results of the first determination made, the count of microbes developing on gelatin at 20° C. in 4 days, are summarized in Table 1. The results of the study of New York schoolroom air by Profs. Baskerville and Winslow are also included for comparison, since the methods used are identical.

[1] American Journal of Public Health, 3: 78.

[2] Report of the Committee on School Inquiry, Board of Estimate and Apportionment, City of New York, 3; 1911-1913.

TABLE 1.—*Microbes in air from various sources (gelatin, 20° C.).*

[Percentage of samples in each case.]

Number of microbes per cubic foot.	0–25	26–50	51–75	76–100	101–125	126–150	151–175	176–200	201–225	226–250	251–275	276–300	301–325	326–350	351–375	376–400	Over 400
Country	44	25	11	7	7	3	...	...	1	2	...	...	...	...	...	1	...
City	28	24	16	6	8	4	3	1	2	2	3	...	...	...	1	...	2
Offices	42	23	9	2	4	2	2	4	1	1	...	1	...	1	1	...	4
Factories	12	15	20	6	29	3	...	6	...	...	...	3	3	3	...	...	3
Schools	24	17	14	13	10	7	4	2	2	2	1	1	1	...	...	...	2

It will be noted that we have called the organisms found "microbes" and not bacteria. Many observers have distinguished, by the appearance of the colonies, between molds and bacteria. Many mold colonies are, of course, clearly recognizable, but we are inclined to believe that in other cases the distinction can not be made by the eye alone and we have therefore grouped them all together.

The maximum counts recorded, and the only ones over 500, were counts of 700, 705, and 735, all in the business offices. The average for country air was 56; for city street air, 72; for offices, 94; for factories, 113; and for schools, 96.

The country air is evidently freer from microbic life than that of the city streets, and the factory air has clearly the largest content. The offices and schools show an average between the last two, but in the case of the offices it should be noted that the average is the result of a number of low values and a few excessively high ones.

In addition to this determination of the microbes that will develop at 20° C. we also made a count upon litmus-lactose-agar at 37° C. to get the microbes capable of development at body temperature, which would include bacteria from the human mouth. The ratio between the 20°- and the 37°-count is known to be significant in water examinations where a high ratio suggests sewage pollution, but very little is known of this ratio in air. The results of our examinations are indicated in Table 2.

TABLE 2.—*Microbes in air from various sources (lactose-litmus-agar, 37° C.).*

[Percentage of samples in each case.]

Number microbes per cubic feet.	0–25	26–50	51–75	76–100	101–125	126–150	151–175	176–200	201–225	226–250	251–275	276–300	301–325	326–350	351–375	Over 400
Country	72	13	5	4	...	1	...	1	...	1	...	...	1	...	...	1
City	60	22	12	3	1	...	...	1	1	1	...	...	...	1	...	...
Offices	64	13	2	5	6	1	1	...	...	3	...	...	...	...	1	5
Factories	49	23	6	11	3	6	...	...	...	...	...	...	...	...	...	3

Four of the counts recorded were over 500; one of 5,200 was in the country; two of 1,070 and 1,647, respectively, were in one of the commercial offices, and one of 885 was in the cigar factory.

The average value for the country air was 30 microbes per cubic foot; for the city streets, 32; for the offices, 80;

and for the factories, 63. As before, the country air is distinctly freer from microbic life than the atmosphere of the city, although a single high value for the country brings their general averages close together. The factory air is higher in content than any other group, so far as the general distribution of results is concerned. The office samples, as before, show many very low and a few very high counts, the latter bringing the average up above even that for factories.

The ratio of the 37°-count to the 20°-count was about 1 to 1.9 for country air, 1 to 2.4 for city air, 1 to 1.2 for the offices, and 1 to 1.8 for the factories. All these ratios are high in comparison with those we find in water of good quality.

Finally, we made an estimate of the number of mouth streptococci present by isolating pure cultures from any colonies characteristic of this group upon the litmus-lactose-agar plates and studying their morphology and fermentation reactions. The lactose fermenting organisms when found in air appear to be chiefly derived from the human mouth and to be reasonably good indices of mouth pollution of the atmosphere. The results of this study are indicated in Table 3 with a summary of the 20° and 37° averages previously discussed.

TABLE 3.—*Average microbic content of the air from various sources.*

Samples.		Microbes per cubic foot.		Streptococci per 100 cubic feet.
Source.	Number.	20° C.	37° C.	
Country	85	56	30	12
City	134	72	32	11
Offices	87	94	80	22
Factories	47	113	63	43
Schools	684	96	....	30

So far as the presence of mouth streptococci is concerned, there is a clear distinction between outdoor and indoor air, the former having less than half as many streptococci as the latter, while the factory air is more polluted than the air of the offices and schools.

Conclusions.

In general it may be concluded from this survey of the microbic content of 353 samples of air from various sources that:

1. The number of microbes developing at 20° C. from outdoor air in suburban districts is generally under 50 per cubic foot and rarely over 100.

The count at 37° C. for such air is about half that at 20° C. and rarely over 50 per cubic foot. The number of mouth streptococci in such air is small—in the neighborhood of 10 per 100 cubic feet. The air from more remote regions would no doubt show still smaller numbers.

2. The air of city streets shows a slightly higher number of microbes, but the general relations are much the same in all the respects noted above.

3. The air of occupied spaces shows, as might be expected, larger average numbers of bacteria and much greater fluctuations. The 20°-count may average over 100 microbes per cubic foot, as in the factories studied, and may reach 700 or more, as in some of the offices. The 37°-count averaged over 50 both in factories and offices and was nearly as high as the 20°-count in the latter case. A few very high 37°-counts were obtained, two between 1,000 and 2,000 in offices, and one of 5,200 in the country, the latter clearly abnormal. Mouth streptococci are much more abundant in indoor air, ranging from 20 to 40 per 100 cubic feet of air, and the results bear out the conclusion that the number of these organisms furnishes a good measure of mouth pollution due to concentration of population in confined spaces.

THEORETICAL METEOROLOGY: MORE PARTICULARLY THE THERMODYNAMICS OF THE ATMOSPHERE.

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[Dated: Kgl. Preussisches Meteorologisches Institut, Berlin, July 12, 1893.]

[The late Wilhelm von Bezold was born June 21, 1837, at Munich, and died at Berlin on February 17, 1907, at the age of 69. At the time of his death he was director of the Royal Prussian Meteorological Institute and professor of meteorology in the University of Berlin, a position he had held since 1885. From 1868 to 1885 he was professor of physics in the Technische Hochschule at Munich, Bavaria, where he had also been actively engaged from 1879 to 1885 in organizing and directing the Bavarian meteorological réseau and service. A brief notice of his work is given in the MONTHLY WEATHER REVIEW for February, 1907, 35:73.

The present paper was prepared for publication between 1901 and 1912, but publication has been delayed for the reasons stated in the MONTHLY WEATHER REVIEW for February, 1914, 42:93.]

Strictly speaking, theoretical meteorology—except meteorological optics and the study of atmospheric electricity—is nothing but a most complicated hydrodynamic and thermodynamic problem.

The condition existing at a certain point of the atmosphere at any given moment is fully determined by the pressure of the air, its temperature, the amount and character of the moisture contained in a unit of volume, and the direction and velocity of motion.

If these elements are also given for neighboring points of space, or specially the changes that occur in the passage from a given place to another adjoining it, and if one also knows the amount of heat that is added to or abstracted from the particle of the atmosphere under consideration in a unit of time, then one has all the elements that determine the change in the given conditions of the air. If it were possible to unite these quantities in an equation it would be regarded as the fundamental equation of the whole of the theoretical meteorology.

However, even if one should succeed in formulating it, this equation could never attain a practical value, since it would be so involved that a discussion of it would be attended with the greatest difficulties. It would at all events be necessary to subsequently introduce most extensive simplifications and then to disregard first one and then another of the variables occurring in it. Therefore, it has not yet been even attempted to attack the problem from so general a point of view but rather to follow the opposite path. Special cases have been selected in which sometimes one and sometimes another group of the elements above enumerated have been omitted from consideration, and thus the great problem has been resolved into separate problems and general theoretical meteorology has been treated in separate sections.

In this manner the statics and dynamics of the atmosphere, as well as the thermodynamics, have been developed as disconnected studies. This separation is not based on the nature of the subject but is rather only a consequence of the impossibility of attacking the problem in its complete generality. It is precisely because this separation has no natural basis that it introduces many impossibilities, one may even say, dangers. It is